

BIRD SPECIES DIVERSITY ALONG THE HIMALAYA: A COMPARISON OF HIMACHAL PRADESH WITH KASHMIR

(With two text-figures and two plates)

TREVOR PRICE^{1,2}, JENNIFER ZEE¹, KARTIKA JAMDAR³ AND NITIN JAMDAR^{3,4}

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About 80% of the birds of the Indian subcontinent can be found within the Himalayan region. We studied variation in bird numbers along the Himalaya. There are more than twice as many species in the east than there are in the west. Most of the decline in species numbers from east to west occurs between western Nepal and northern Pakistan, where the trend of the Himalaya follows a more northerly course. We compared the breeding birds of two sanctuaries across this region of steep decline in species numbers, Manali in Himachal Pradesh, whose birds are described for the first time in this paper and Overa in Kashmir (Price and Jamdar 1990, 1991). Differences in species' composition are large, e.g. one-third of the high elevation (c. 3,000 - 3,500 m) species were recorded from only one or other sanctuary. Some of the missing species from one or other sanctuary were not a consequence of a range limit between the sanctuaries, but rather a result of a gap in the distribution. Species with patchy distributions included the western tragopan *Tragopan melanocephalus* whose range was historically known to be much more extensive, and the Nepal wren-babbler *Pnoepyga immaculata*. We conclude that there is considerable variation in species composition along the Himalaya and this is being accentuated by local population extinctions.

INTRODUCTION

Large numbers of bird species live in the Himalaya (Meinertzhagen 1928, Inskipp and Inskipp 1985, Martens and Eck 1995). In addition, species composition varies along the Himalaya and there are many more species in the east than in the west (Inskipp and Inskipp 1985). While this pattern is qualitatively known, it has not been quantified, and its underlying cause is not understood. In this paper, we investigate variation in species number along the Himalaya. We use a broad scale comparison based on published species range maps to document general patterns, and then a more detailed comparison of two sites in the Northwest Himalaya (in Himachal Pradesh and Kashmir) where we have conducted fieldwork over the past

15 years. We investigate how total species numbers change along the Himalaya and the extent to which species composition varies between different localities.

Although the Himalayan range is often considered to run from east to west, particularly from Nepal west it follows a southeast to northwest trend, and spans c. 5 degrees latitude from western Nepal to Srinagar in Kashmir (Plate 1, Fig. A and Plate 2, Fig. B). As we will show, total species numbers along the Himalaya decline mostly in association with this latitudinal gradient, rather than with longitude. The two sites we worked at (Manali Sanctuary in Himachal Pradesh and Overa Sanctuary in Kashmir) are located in a region where there is a steep decline in species numbers. The data from Overa have been previously published (Price and Jamdar 1990, 1991), but the data from Manali are presented here for the first time. Therefore, a second purpose of this paper is to document the breeding birds (including range extensions and altitudinal distributions) for Manali Sanctuary for which there is no previously published ornithological survey.

¹Section of Ecology, Evolution and Behavior,
Division of Biological Sciences, 0116
University of California at San Diego,
La Jolla CA 92093-0116, USA.

²Email: tprice@ucsd.edu

³5-A Samata, Gen. Bhosale Marg, Mumbai 400 021, India.

⁴Email: nitinjamdar@yahoo.com

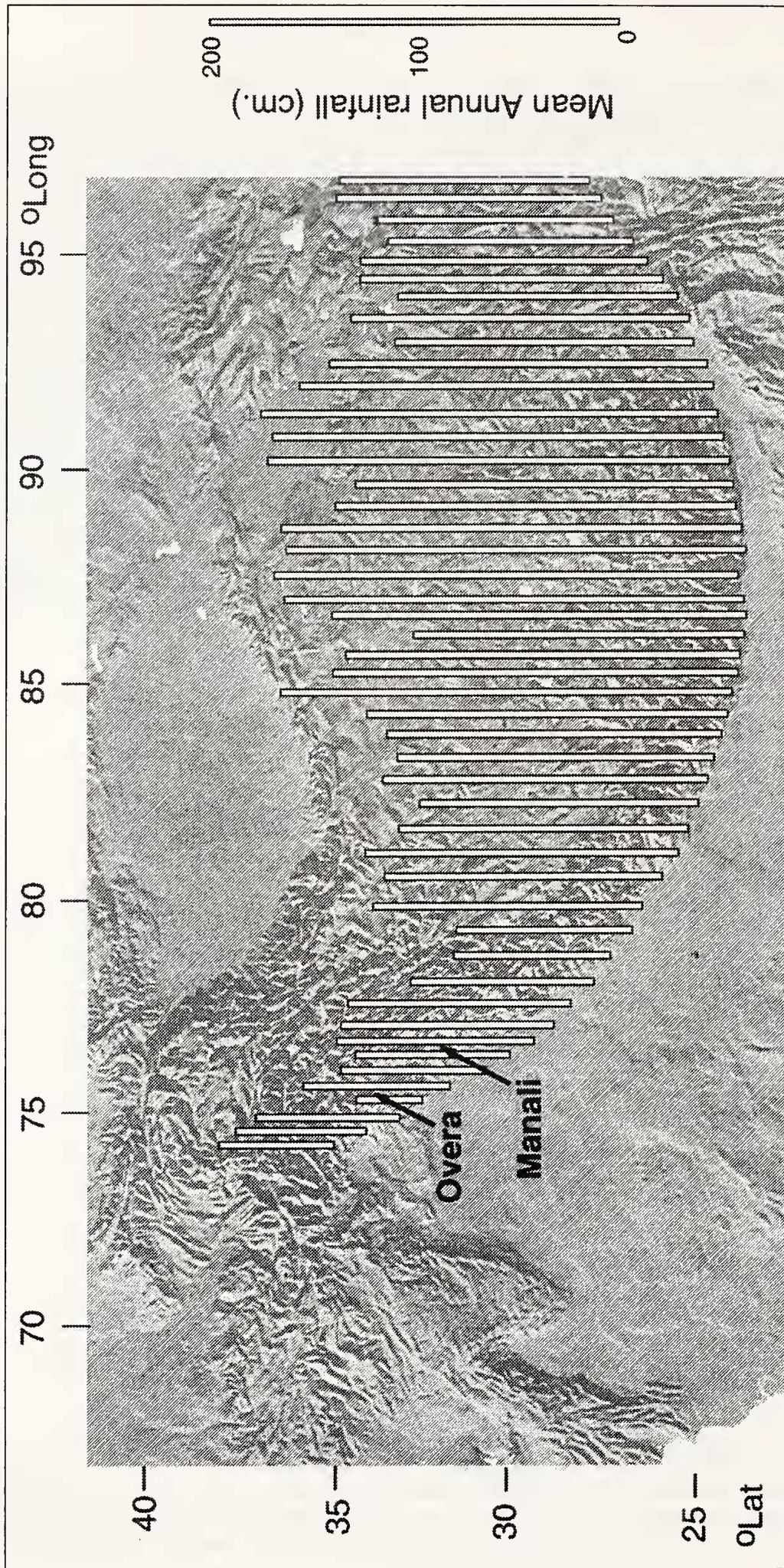


Fig. B: Locations of the two long-term study sites and annual precipitation estimated for half-degree coordinates along the Himalaya (see New *et al.* 1999, 2000)

METHODS

Broad-scale comparisons

Taxonomy and nomenclature throughout this paper follow Sibley and Monroe (1990). We used a field guide (Grimmett *et al.* 1999a) to estimate the numbers of breeding bird species at different locations in the Indian subcontinent. We excluded species that were primarily pelagic, leaving us with a dataset of 976 breeding species that we considered to be dependent on land or freshwater. The species used and the data collected are available at <http://www.biology.ucsd.edu/tprice>. Following the methods of Fjelds  (1994), we overlaid a transparent grid of 14 squares x 14 squares on each map in the field guide. Each square is approximately 250 km x 250 km. Plate 1, Fig. A shows the grid with the approximate position of the squares (position is approximate because the map projection used by Grimmett *et al.* (1999a) differs from the one used here). Then we recorded the presence or absence of the species in each square. With this information, we were able to calculate the number of breeding species in each square, and the extent to which different squares share species. We also used Ali and Ripley (1987) and Grimmett *et al.* (1999b) to assess the altitudinal bands in which a species is found (divided into 1,000 m intervals). For many species altitudinal distributions vary considerably along the Himalaya (Martens and Eck 1995). We ignored this spatial variation, simply recording minimum and maximum elevations as far as are known.

We obtained climate data described in New *et al.* (1999, 2000) and available at <http://mercury.ornl.gov/ornl/daac>. This dataset provides (extrapolated) mean monthly averages for eleven climate variables at 0.5° latitude and longitude intervals across the whole land surface of the world. We based our analysis on measurements made between 1901 and 1960. We extracted mean annual precipitation for points along the Himalaya. We also used measurements

of climate reported for individual meteorological stations in the Himalaya (Anon. 1967).

Field studies

The two study sites are Overa (33° 80' N, 75° 40' E) near Pahalgam in Kashmir, and Manali (32° 20' N, 77° 20' E) in Himachal Pradesh (Plate 2, Fig. B), 250 km to the southeast of Overa.

Overa Sanctuary (33 sq. km) forms the watershed to a small valley running approximately northwest to southeast (Price and Jamdar 1990). The elevation spans from about 2,400 m to above the treeline. We were camped at sites at approximately 2,400 m or 3,300 m from May to July in each of the three years from 1985-1987, as described in Price and Jamdar (1990, 1991). Either TP or NJ returned to Overa for a period of 1-2 months (May or May-June) in each of the subsequent four years, from 1988-1991. Our latest observations confirmed the previous findings, with a few additions reported in Appendix I.

Manali Sanctuary (32 sq. km) is a watershed similar in size to Overa, but the main river runs west to east (Singh *et al.* 1990). The altitudinal range is from *c.* 2,000 m (just outside the town of Manali) to above the treeline. We spent the following periods in Manali Sanctuary, camped at 3,100 m: May-June 1994 (TP), early May 1995 (TP), late June 1996 (TP), late June - early July 1997 (TP), May-June 2001 (TP, NJ, KJ), and May 2002 (NJ, KJ).

We recorded all the birds observed in a daily logbook. We estimated bird abundance using point censuses and mistnet capture rates, but found the most satisfactory measure to be simply the fraction of days a species was observed, which is reported here. This measure is weakly correlated with mistnet captures [correlation coefficient ≈ 0.5 in Overa (Price and Jamdar 1990)].

We made a special effort to assess altitudinal distributions. These are poorly known for the Himalaya, partly because they can vary greatly from place to place (Martens and Eck 1995), and partly because it has been difficult to separate

breeding from winter and migratory records (e.g. Inskipp *et al.* 2000).

Altitudinal distributions must always be approximate. Firstly, they vary even within a valley. For example, south-facing slopes in Manali have much more extensive kharsu oak *Quercus semecarpifolia*, whereas north-facing slopes have more extensive fir *Abies pindrow*, and bird species associated with these habitats have different altitudinal distributions on each side of the valley. In Manali, we worked on a north-facing slope. Secondly, individual singing males may occupy territories far out of the normal range. This is particularly true for estimates of lower boundaries, as occasional males may remain singing and unmated at low elevations until late in the season (see for example, bimodal distribution of *Phylloscopus reguloides* in Fig. 2, probably as a result of 1 or 2 singing males at low elevations, where the species was not generally observed), but may also apply to upper boundaries (for example, a lone *Cettia fortipes* established a territory at c. 3,000 m in Overa). Thirdly, rare species are easily overlooked. In Overa, we attempted to estimate lower and upper altitudinal bounds for each species, based on localities where it appeared that several pairs were likely to be breeding. We based our estimates on repeated observations of birds throughout the 3 years of our initial study, and found these to be upheld in four subsequent seasons. In Manali, we conducted censuses along the entire altitudinal gradient by halting for 2 minutes at intervals of every 25 m altitude (measured using an altimeter), and recording all birds seen and heard (this was conducted over a period of 2-3 mornings from 0600-0900 hrs in each of the three years 1996, 1997 and 2001). We then listed the altitudinal distributions of all species from these censuses, and evaluated the list on a species by species basis in the field in May 2002. Despite all the caveats associated with estimates of altitudinal distributions, species differ considerably in where they live on the mountain, and our estimates are consistent between years.

During the course of the altitudinal census at Manali, we also recorded all tree species within an approximate 8 m radius of the census point.

RESULTS

Broad patterns

The number of species in each square across the Indian subcontinent is shown in Plate 1, Fig. A. Results confirm that the Himalaya harbours a large number of species. Indeed, one 250 km x 250 km square in central Nepal contains 575 species, or 60% of all the land and freshwater species breeding in the Indian subcontinent (including the Andaman and Nicobar Islands) and almost twice the maximum diversity recorded from a square in peninsular India. We combined results from 11 squares running the length of the Himalaya from Pakistan to Arunachal Pradesh (see squares with letter symbols in Plate 1, Fig. A). These 11 squares contain a total of 783 species or 80% of all the species found on the Indian subcontinent. This partly reflects the great range of climate regimes, from tropical to temperate, and hence diversity of habitats. For example, 154 (20%) of the 783 Himalayan species breed entirely above 2,000 m. An additional 249 species (32%) are found breeding above 2,000 m somewhere in their geographical range, as well as at lower elevations. The other species occur at lower altitudes, including the plains of India.

There are many more species in the east than in the west. Across the 11 squares running the length of the Himalaya, the easternmost, in Arunachal Pradesh, contains more than twice the number of species of the westernmost square, in Pakistan (507 vs 233 species). The decrease in species number is mainly from Uttaranchal to northern Pakistan, i.e. where there is a substantial south-north as well as east-west trend of the Himalaya. The square including Uttaranchal contains almost 500 species, similar to the square in Arunachal Pradesh.

The steep decline in species numbers across the Northwest Himalaya is associated with

a decline in precipitation (Plate 2, Fig. B). In Pakistan, the lower reaches of the Himalaya are very dry and semi-desert. In comparison with Nepal, northern Pakistan has much less monsoon rainfall, more winter precipitation and colder winters (Stainton and Polunin 1984).

Superimposed on changes in total species number is species turnover. 116 species occur in both the westernmost and easternmost squares, i.e. Pakistan (PK) and Arunachal Pradesh (AP), implying that 50% of all the species in the Pakistan Himalaya extend their range throughout the Himalaya. There are many more species in Arunachal, and hence a smaller fraction (23%) of these species extend west to Pakistan. Among species recorded breeding above 2,000 m, 63 species range throughout the Himalaya, which is 43% of the Pakistan total (26% of the Arunachal total).

In Fig. 1, we have plotted the turnover between adjacent squares along the Himalaya.

This plot is for all species recorded breeding above 2,000 m altitude somewhere in their geographical range, but the patterns are similar if all species are included. The histograms give the fraction of species in a square that have western or eastern range limits in that square. For example, 30% of the species in the square KM are not found in the square PK whereas 15% of the species in the square KM are not found in the square HP.

Typically about 10% of all species in a square do not extend to the neighbouring square, and patterns of turnover are not strikingly different at different points along the Himalaya or to the east or west. The main exceptions are the squares KM and HP which have a high fraction of species (>30%) that do not extend their ranges to the northwest. Thus, even though some species are confined to the northwest, the southeast to northwest latitudinal gradient in species numbers reflects the fact that larger numbers of southeastern species fail to extend their ranges northwest.

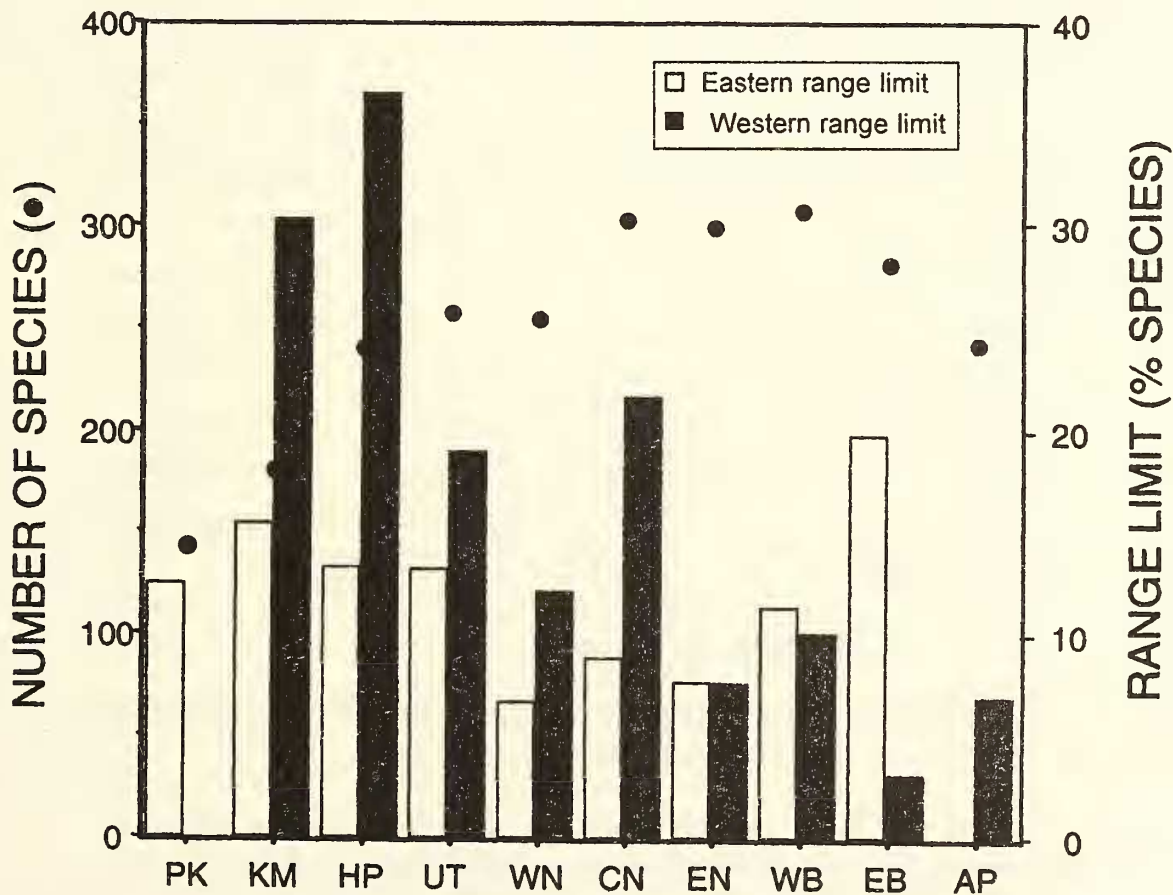


Fig. 1: Species turnover along the Himalaya.

Letter symbols refer to squares indicated in Plate 1, Fig. A, with the two WN squares combined

Himachal Pradesh vs Kashmir

We now investigate the pattern of high species turnover along the Northwestern Himalaya by comparing Manali (Himachal Pradesh) and Overa (Kashmir) Sanctuaries.

Vegetation and climate: The altitudinal distributions of the major tree species for the north-facing slope in Manali are shown in Fig. 2 (for similar data on Overa, see Price and Jamdar 1990, and Price 1991). The vegetation at Manali differs from that at Overa in several ways. Most

strikingly, kharsu oak is common in Manali, but absent in Overa (Price and Jamdar 1990). Rhododendron is much more abundant in Manali than in Overa. Juniper, at least in the area where we worked, is much less common in Manali than in Overa. Among tree species held in common, maple *Acer* spp., fir *Abies* spp., pine *Pinus wallichiana*, spruce *Picea smithiana* and birch *Betula utilis* have similar altitudinal distributions in the two sanctuaries.

We do not have comparable climate

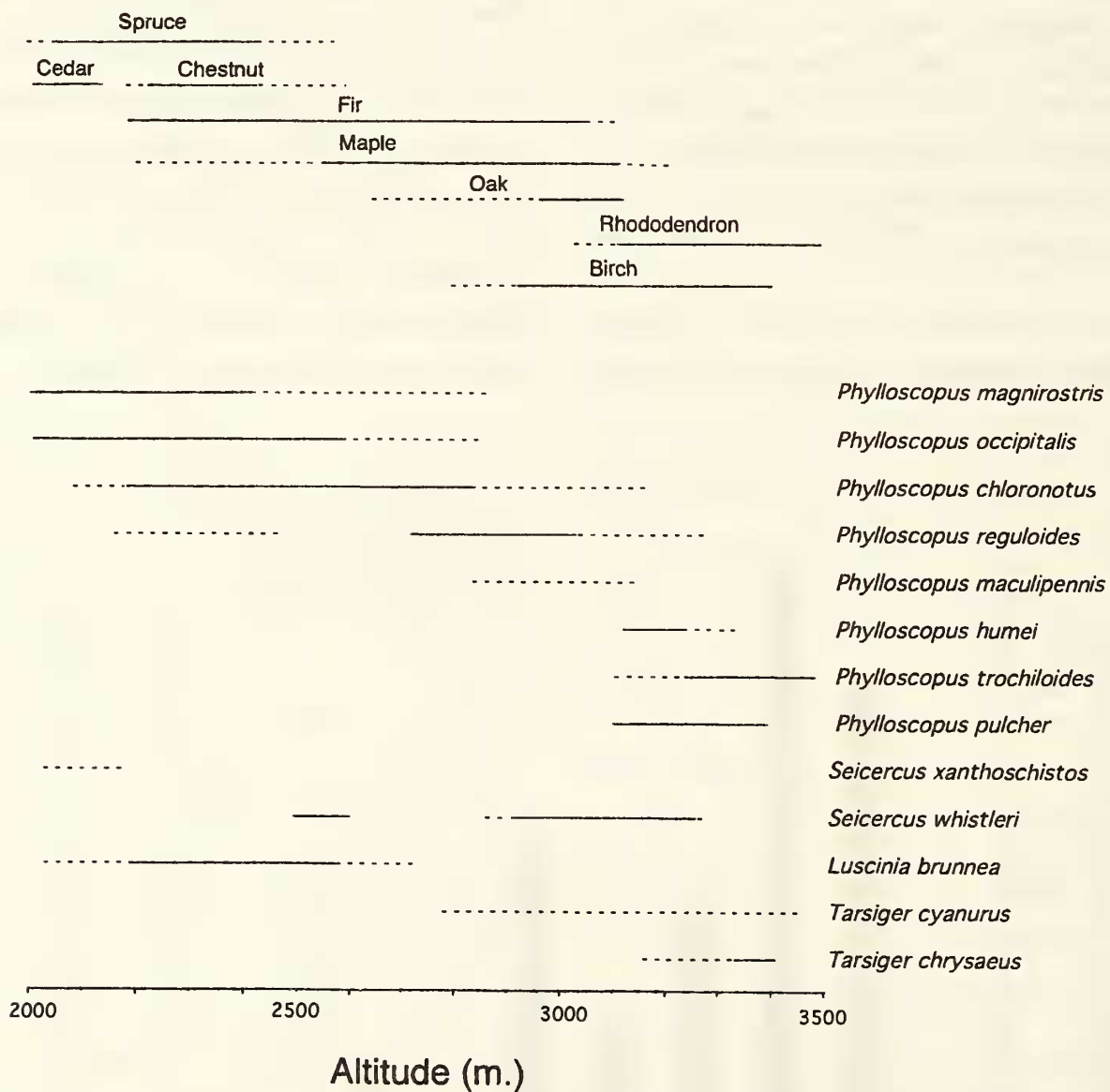


Fig. 2: Distributions of the major tree species along the Manali transect (top) and census records for species of four common bird genera conducted on June 3-5, 1997

Top: ————— = 2 or more individuals recorded within an approximately 8 m radius.
 = the extreme records for the species as observed in the 8 m radius.
 Bottom: ————— = range over which more than one individual was recorded at each census point.
 = the range over which one individual was recorded.
 Two minutes were spent at altitudinal intervals of 25 m along the transect, early in the morning.

measurements from Overa and Manali, partly because they were studied over different years and the climate may have been changing: snow disappeared from our camp in Manali approximately one month earlier in each year of 2001-2002 than in each year of 1994-1997 (see also Vedwan and Rhoades 2001). Nevertheless, Manali is probably wetter (Plate 2, Fig. B) and warmer than Overa. To assess this indirectly, we compared climate records for Shimla, Himachal Pradesh (31°N, 77°E) with Srinagar, Kashmir (34°N, 75.5°E), based on 30 years of data (1931-1960; Anon. 1967). Although Shimla is 700 m higher, it has warmer springs (average minimum temperature in May in Shimla is 4 °C higher than in Srinagar) and almost three times the annual rainfall of Srinagar.

Birds of Manali Sanctuary: We recorded a total of 137 species in or near Manali Sanctuary. The data are summarised in four exclusive lists. In Table 1, we present the 81 species encountered above about 2,800 m (higher elevations) in at least two different years with altitudinal distribution and estimates of abundance. Table 2 lists common breeding species in the forests below 2,500 m, with altitudinal distribution. These tables are separated

because we spent little time at the lower altitudes, have less quantitative data, and may well have overlooked some species. Appendix II refers to additional species that have been recorded rarely in Manali Sanctuary and Appendix III additional species that primarily breed along the lower boundary of Manali Sanctuary in more open habitat.

In Fig. 2 we show altitudinal distributions based on a single census for common species belonging to four genera. Some species appear to be tightly associated with particular habitats, such as *Phylloscopus humei* with birch (Price and Jamdar 1991). Two species are particularly noteworthy. The first, *Seicercus whistleri*, appears to have a disjunct altitudinal distribution (Fig. 2). This was noted further east in the Himalaya by Alström and Olsson (1999) and Martens *et al.* (1999) who described the lower elevation population as a separate species (*Seicercus burkii*); the upper population is now classified as *Seicercus whistleri*; (see also Alström and Olsson 2000). The possibility that both species are present in Manali needs to be investigated. Secondly, there is a breeding population of the Nepal wren-

Table 2: Common forest bird species in the lower part of Manali Sanctuary that do not extend to higher elevations*

Common name	Latin name	Altitudinal distributions (in m)	
		Low	High
² Great barbet	<i>Megalaima virens</i>	2,200	2,275
² Ashy drongo	<i>Dicrurus leucophaeus</i>	2,075	2,150
¹ Blue-headed rock-thrush	<i>Monticola cinclorhynchus</i>	2,100	2,175
² Grey-winged blackbird	<i>Turdus boulboul</i>	1,975	2,075
¹ Rusty-tailed flycatcher	<i>Muscicapa ruficauda</i>	-	2,240
¹ Verditer flycatcher	<i>Eumyias thalassina</i>	2,000	2,450
² Grey-headed flycatcher	<i>Culicicapa ceylonensis</i>	2,280	2,575
¹ Green-backed tit	<i>Parus monticolus</i>	1,975	2,500
¹ Black bulbul	<i>Hypsipetes leucocephalus</i>	2,150	2,450
² Grey-hooded flycatcher-warbler	<i>Seicercus xanthoschistos</i>	2,050	2,150
Nepal wren-babbler	<i>Pnoepyga immaculata</i>	2,300	2,600
Yellow-naped yuhina	<i>Yuhina flavicollis</i>	2,175	2,375

¹Present also in Overa. *Muscicapa ruficauda* is much more common in Overa than Manali.

²These species were not recorded in Overa, but are common elsewhere in Kashmir and their absence may reflect the absence of forest habitat below 2,400 m in Overa.

*For additional common species that extend into Manali town, see Appendix III.

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Table 1: Common species found above 2,500 m in Manali Sanctuary
Comparative information for Overa is from Table 4 of Price and Jamdar (1990)

Common name	Latin name	Abundance		Altitudinal distributions (in m)			
		¹ Manali	*Overa	Manali		Overa	
				Low	High	Low	High
Western tragopan	<i>Tragopan melanocephalus</i>	26	² A.	3,100	3,100	-	-
Koklass pheasant	<i>Pucrasia macrolopha</i>	63	25	2,360	3,300	2,400	3,200
Impeyan monal	<i>Lophophorus impejanus</i>	79	47	2,725	3,250	3,000	3,500
Himalayan pied woodpecker	<i>Dendrocopos himalayensis</i>	38	22	2,575	3,100	2,400	3,300
Large scaly-bellied green woodpecker	<i>Picus squamatus</i>	25	7	2,430	3,100	2,400	3,200
Common cuckoo	<i>Cuculus canorus</i>	77	49	2,090	3,100	2,400	3,200
Lesser cuckoo	<i>Cuculus poliocephalus</i>	68	53	1,975	2,900	3,000	3,700
Himalayan swiftlet	<i>Collocalia brevirostris</i>	31	⁴ Not seen	-	-	-	-
Pacific swift	<i>Apus pacificus</i>	7	1	-	-	-	-
Tawny wood-owl	<i>Strix aluco</i>	5	32		3,100	2,400	3,400
Collared owlet	<i>Glaucidium brodiei</i>	4	10	2,300	2,800	2,400	3,400
Oriental turtle-dove	<i>Streptopelia orientalis</i>	26	34	1,975	3,125	2,400	3,200
Eurasian woodcock	<i>Scolopax rusticola</i>	70	54	3,100	3,250	3,000	3,400
Bearded vulture	<i>Gypaetus barbatus</i>	12	45	-	-	-	-
Himalayan griffon	<i>Gyps himalayensis</i>	35	66	-	-	-	-
Eurasian sparrowhawk	<i>Accipiter nisus</i>	14	13	2,000	3100	2,400	3,300
Buzzard sp.	<i>Buteo</i> sp.	1	47	-	-	-	-
Golden eagle	<i>Aquila chrysaetos</i>	13	23	-	-	-	-
Booted eagle	<i>Hieraaetus pennatus</i>	7	2	-	-	-	-
Common kestrel	<i>Falco tinnunculus</i>	4	32	-	-		3,300
Spotted nutcracker	<i>Nucifraga caryocatactes</i>	65	75	2,800	3,100	3,100	3,500
Red-billed chough	<i>Pyrrhocorax pyrrhocorax</i>	13	15	-	-	-	3,600
Jungle crow	<i>Corvus macrorhynchos</i>	100	91	1,975	3,200	2400	3,600
Long-tailed minivet	<i>Pericrocotus ethologus</i>	65	20	1,975	3,275	2,400	3,300
Chestnut-bellied rock-thrush	<i>Monticola rufiventris</i>	48	4	3,100	3,100	3,200	3,400
Blue whistling-thrush	<i>Myiophonus caeruleus</i>	56	57	1,975	3,125	2,400	3,300
Plain-backed thrush	<i>Zoothera mollissima</i>	32	9	3,155	3,425	3,400	3,700
Scaly thrush	<i>Zoothera dauma</i>	71	19	3,100	3,100	3,000	3,200
White-collared blackbird	<i>Turdus albocinctus</i>	98	Abs.	2,700	3,425	-	-
Eurasian blackbird	<i>Turdus merula</i>	1	10	3,850	3,850	3,500	3,700
Mistle thrush	<i>Turdus viscivorus</i>	6	² Abs.	3,130	3,450	-	-
Yellow-bellied fantail-flycatcher	<i>Rhipidura hypoxantha</i>	100	Abs.	3,100	3,300	-	-
Sooty flycatcher	<i>Muscicapa sibirica</i>	29	31	2,600	3,240	2,400	3,300
Orange-gorgeted flycatcher	<i>Ficedula strophilata</i>	94	Abs.	2,500	3,250	-	-
Ultramarine flycatcher	<i>Ficedula superciliiaris</i>	33	24	1,975	3,125	2,400	3,300
Slaty-blue flycatcher	<i>Ficedula tricolor</i>	46	56	2,750	3,375	2,400	3,300
Indian blue robin	<i>Luscinia brunnea</i>	63	42	1,995	3,425	2,400	3,400
Orange-flanked bush robin	<i>Tarsiger cyanurus</i>	100	97	2,725	3,525	3,000	3,500
Golden bush-robin	<i>Tarsiger chrysaesus</i>	69	² Abs.	3,140	3,475	-	-
Blue-fronted redstart	<i>Phoenicurus frontalis</i>	8	28	3,150	3,940	-	3,400
White-capped redstart	<i>Chaimarrornis leucocephalus</i>	2	13	3,200	3,200	2,800	3,100
White-bellied redstart	<i>Hodgsonius phaenicuroides</i>	2	23	3,100	3,100	3,200	3,500
White-cheeked nuthatch	<i>Sitta leucopsis</i>	42	29	2,680	3,100	2,400	3,300
⁵ Bar-tailed treecreeper	<i>Certhia himalayana</i>	62	1	1,975	3,250	2,400	3,200
⁵ Eurasian treecreeper	<i>Certhia familiaris</i>	40	65	3,100	3,210	3,300	3,500

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Table 1: Common species found above 2,500 m in Manali Sanctuary
Comparative information for Overa is from Table 4 of Price and Jamdar (1990) (contd.)

Common name	Latin name	Abundance		Altitudinal distributions (in m)			
		¹ Manali	*Overa	Manali		Overa	
				Low	High	Low	High
Winter wren	<i>Troglodytes troglodytes</i>	62	95	3,100	3,375	3,000	3,700
Fire-capped tit	<i>Cephalopyrus flammiceps</i>	10	16	2,490	3,100	2,400	3,300
Rufous-bellied crested tit	<i>Parus rubidiventris</i>	90	6	3,050	3,300	3,300	3,500
Spot-winged crested tit	<i>Parus melanolophus</i>	94	89	2,175	3,325	2,400	3,300
Brown crested tit	<i>Parus dichrous</i>	24	Abs	3,100	3,160		
White-throated tit	<i>Aegithalos niveogularis</i>	23	41	3,240	3,365	3,200	3,500
Northern house martin	<i>Delichon urbica</i>	48	48	3,100	3,500		3,500
Goldcrest	<i>Regulus regulus</i>	51	21	2,150	3,275	2,400	3,300
Chestnut-headed tesia	<i>Tesia castaneocoronata</i>	79	Abs.	2,300	3,260		
Aberrant bush-warbler	<i>Cettia flavolivacea</i>	24	Abs.	3,230	3,230		
Grey-sided bush-warbler	<i>Cettia brunnifrons</i>	44	² Abs.	3,230	3,230		
Spotted bush-warbler	<i>Bradypterus thoracicus</i>	35	Abs.	3,100	3,730		
Orange-barred leaf-warbler	<i>Phylloscopus pulcher</i>	100	70	3,050	3,475	3,300	3500
Grey-faced leaf-warbler	<i>Phylloscopus maculipennis</i>	52	Abs.	2,800	3,230		
Lemon-rumped warbler	<i>Phylloscopus chloronotus</i>	100	77	2,150	3,300	2,400	3,300
Hume's warbler	<i>Phylloscopus humei</i>	100	97	2,900	3,430	2,400	3,500
Greenish leaf-warbler	<i>Phylloscopus trochiloides</i>	73	62	3,100	3,550	3,300	3,500
Large-billed leaf-warbler	<i>Phylloscopus magnirostris</i>	80	54	2,175	3,025	2,400	3,500
Western crowned warbler	<i>Phylloscopus occipitalis</i>	8	91	1,975	2,900	2,400	3,300
Blyth's leaf-warbler	<i>Phylloscopus reguloides</i>	100	Abs.	2,625	3,250		
³ Gold-spectacled flycatcher-warbler	<i>Seicercus whistleri</i>	100	1	2,500	3,275		
Variiegated laughingthrush	<i>Garrulax variegatus</i>	92	84	2,325	3,500	2,400	3,500
Red-headed laughingthrush	<i>Garrulax erythrocephalus</i>	10	Abs.	3,200	3,220		
Greater scaly-breasted wren-babbler	<i>Pnoepyga albiventer</i>	90	Abs.	2,785	3,350		
Bar-throated minla	<i>Minla strigula</i>	100	Abs.	2,725	3,450		
Oriental tree pipit	<i>Anthus hodgsoni</i>	83	Abs.	3,100	3,485		
Rosy pipit	<i>Anthus roseatus</i>	11	16	3,350	4,060	3,500	
Rufous-breasted accentor	<i>Prunella strophia</i>	49	89	3,140	3,425	3,200	3,700
Hodgson's mountain-finch	<i>Leucosticte nemoricola</i>	17	36	3,025	3,500	3,500	
Spectacled finch	<i>Callacanthus burtoni</i>	36	5	2,580	3,140	2,800	3,700
Dark-breasted rosefinch	<i>Carpodacus nipalensis</i>	58	1	3,150	3,700		
Pink-browed rosefinch	<i>Carpodacus rodochrous</i>	71	77	3,225	3,375	2,400	3,700
Red-headed bullfinch	<i>Pyrrhula erythrocephala</i>	38	Abs.	2,930	3,250		
Collared grosbeak	<i>Mycerobas affinis</i>	1	Abs.	3,100	3,275		
Black-and-yellow grosbeak	<i>Mycerobas icterioides</i>	38	83	2,200	3,155	2,400	3,700
Spotted-winged grosbeak	<i>Mycerobas melanozanthos</i>	14	² Abs.	2,100	3,100		

¹ Proportion of days observed when camped at 3,100 m. Based on n = 84 days; 34 days in June/July 1996 and 50 days in May/June 2001.

* Proportion of days observed when camped at 3,300 m (n=224 days in 1985-1987).

² Although absent from Overa the species has been recorded as breeding (rarely) in Pakistan (Roberts 1991, 1992)

³ A single singing male present at Overa in several years.

⁴ We did not observe this species as we paid little attention to the swifts, nevertheless it may have been present at Overa, which is close to its range limit.

⁵ We did not always distinguish between *Certhia himalayana* and *Certhia familiaris*.

babbler *Pnoepyga immaculata* between c. 2,300 m and 2,600 m in the chestnut-spruce-fir woods just above the entrance to the Sanctuary (mostly between 2,300 m and 2,450 m). This species was first described in 1991 (Martens and Eck 1991) and previously only recorded from Nepal. An individual was captured and examined in the hand on May 22, 2001 (wing-length 55 mm, weight 15 g).

Comparison of Manali with Overa: In our study, Manali and Overa can be best compared in the composition of higher elevation species (c. 3,000 m - 3,500 m), the habitat being less disturbed, and because we spent much more time at these elevations. For Manali this includes all 81 species in Table 1. There are an estimated 70 common species at Overa at these elevations (see Table 4 in Price and Jamdar 1990).

Twenty-one species are present on the Manali higher elevation list but not in Overa, and 11 species are present on the Overa higher elevation list but not in Manali. Fifty-nine species are included in the lists from both Manali and Overa. Thus 64% of the total number of species in the two sanctuaries combined are found in both sanctuaries and 36% are found in one or other sanctuary.

High elevation Manali species missing from Overa: Of the 21 species present at high elevations in Manali and not in Overa, 5 have been recorded breeding in northern Pakistan (Roberts 1991, 1992). Apart from *Tarsiger chrysaeus*, the remaining 4 (see Table 1) are rare in Manali and may occasionally occur in Overa but may have been overlooked. However, they may also reflect a genuinely patchy distribution, perhaps due to recent extinctions. *Tragopan melanocephalus* is one such example: we never recorded the species in Overa, but there is a small breeding population in Pakistan (Roberts 1991).

One species, *Collocalia brevirostris*, has its range limit in Kashmir, but may have been present in Overa and been overlooked by us. A general feature of many of the species absent or

rare in Overa is that they are very common in Manali. Six of them were among the 15 that we recorded on more than 90% of the days (Table 1). For example, *Minla strigula* and *Rhipidura hypoxantha* are two of the commonest species at Manali, but they have never been recorded breeding as far west as Overa. Causes of the absence of these and most of the other species are not understood. It is notable that several ground and bush foraging insectivores that are common in Manali are missing from Overa (*Anthus hodgsoni*, *Pnoepyga immaculata*, *Tesia castaneocoronata*, *Cettia flavolivacea*, *Bradypterus thoracicus*).

The absence of two species from Overa (*Turdus albocinctus* and *Pyrrhula erythrocephala*) is associated with the presence of an ecologically similar species in similar habitat there (compare Table 1 with Table 3). *Turdus albocinctus* is replaced by *Turdus rubrocanus* in Overa. In 1996, a pair of *T. rubrocanus* was found breeding in Manali and males of the two species were observed chasing each other. Both these species have similar songs and may mutually exclude each other. Note, however, that *T. rubrocanus* does occur east through Nepal (Ali and Ripley 1987), and both *T. rubrocanus* and *T. albocinctus* breed in similar habitat in Bhutan (Inskipp *et al.* 2000). The absence of other species may be related to the absence of their preferred habitat. In particular, *Phylloscopus maculipennis* and *P. reguloides* are typically found in association with kharsu oak that is absent from Overa and further west.

High elevation Overa species missing from Manali: Eight of the 11 species present at high elevations in Overa but not present at high elevations in Manali are given in Table 3. Of the other three species, *Garrulax lineatus* and *Emberiza cia* are present and common in Manali, but only at low elevations (Appendix III). The third species missing from Manali, but not listed in Table 3, is *Phoenicurus caeruleocephalus*, which is very rare in Overa.

Table 3: Species common in Overa but absent or rare in Manali

Common name	Latin name	¹ Abundance	
		Overa	Manali
Common swift	<i>Apus apus</i>	20	0
^{2,4} Chestnut thrush	<i>Turdus rubrocanus</i>	83	7
*Kashmir flycatcher	<i>Ficedula subrubra</i>	0	0
⁴ Himalayan rubythroat	<i>Luscinia pectoralis</i>	37	0
* ⁴ Kashmir nuthatch	<i>Sitta cashmirensis</i>	0	0
⁴ Simla crested tit	<i>Parus rufonuchalis</i>	30	0
Tytler's leaf-warbler	<i>Phylloscopus tytleri</i>	74	0
^{4,5} White-browed rosefinch	<i>Carpodacus thura</i>	9	0
Orange bullfinch	<i>Pyrrhula aurantiaca</i>	47	0
^{3,4} Tickell's warbler	<i>Phylloscopus affinis</i>	69	1

¹Abundance at the high altitude sites (c. 3,200 m). See Table 1 for explanation.

*Common below 3,000 m in Overa (Price and Jamdar 1990) but never observed in Manali.

²In Manali, a nest with 3 eggs found at 3,500 m on June 18, 1996; an individual seen at 3,240 m on May 15, 2002.

³In Manali, a pair breeding in a small patch of juniper in 1994, and a single singing male in early May, 1995. May be common elsewhere in the Sanctuary where there is much juniper.

⁴Recorded breeding as far east as Nepal (Grimmett *et al.* 1999b).

⁵Two individuals seen near Manali town on May 8, 2002.

Eight of the 11 high-elevation species absent from Manali actually have ranges extending into Nepal, and their absence from Manali is attributable to patchy distribution. Causes of absence of these species from Manali are generally unclear, but several species have ecologically similar replacements (as noted in the previous section). Two species that are common in Overa, *Phylloscopus affinis* and *Luscinia pectoralis*, occur in juniper habitat which was rare at our study site in Manali. Both species have ranges extending through Nepal, and the patchiness in their distribution reflects the same in habitat distribution.

The three species present in Overa, but missing from Manali, which do not extend east are *Apus apus* (we have an unconfirmed sight record of this species in Manali), *Phylloscopus tytleri* and *Pyrrhula aurantiaca*. All three species are common in Overa. As in the case of Manali species not present in Overa, species abundant in one sanctuary are often absent from the other.

Altitudinal ranges: In general, and within the limits of our ability to accurately estimate

altitudinal ranges, species that occur in both locations occupy similar altitudinal distributions. In particular, relative placements of congeners are never altered. There are three examples of large differences in altitudinal distribution between populations of the same species. All of these involve species in Overa extending to higher altitudes than in Manali (*Phylloscopus occipitalis*, *Garrulax lineatus* and *Emberiza cia*). Manali has the generally warmer climate, so we expected species at low elevations in Overa to have higher altitudinal distributions in Manali, but we found no clear examples of this pattern. It is possible that, given the lower species diversity in Overa, the altitudinal range extensions there are a response to reduced competition.

Similarities between sites: We calculated similarity indices (Magurran 1988, p. 95) between high and low elevations at Manali and Overa (Table 4). We restricted this analysis to passerines, which provide a more homogeneous set. The similarity indices are designed to run from 0 to 1. If there were an equal number of species in each site, all at the same density, an index of 0.5 would

Table 4: Similarities between sites for passerine birds

	High Overa	Low Overa	High Manali	Low Manali
High Overa	-	0.36	0.63	0.28
Low Overa	0.51	-	0.25	0.59
High Manali	0.59	0.35	-	0.23
Low Manali	-	-	-	-
Total species	53	38	63	35

Data from Table 4 of Price and Jamdar (1990) and Tables 1-3 in this paper.

Above the diagonal: Jaccard's index = (number shared species/total number species)

Below the diagonal: Morisita-Horn index, which weights species by their density (see Magurran 1988)

Densities were the fraction of days observed. This data is not available for low Manali.

Low sites are centred at approximately 2,400 m, high sites at approximately 3,200 m.

Low sites have fewer species because only forest species were included.

imply that half the species are present in both sites. Similarities within elevations across sites are about 0.6. Similarities between elevations run from 0.23 to 0.51 (true similarities are lower because only genuinely forest species are included for the lower sites; species of more open land are excluded). A shift in approximately 1,000 m elevation clearly results in more species' turnover than the shift of 250 km between Manali and Overa.

DISCUSSION

In South America, bird diversity is correlated with topography, precipitation and an interaction between topography and latitude (Rahbek and Graves 2001). The most diverse locality is in the Andes on the equator, which has: i) very high rainfall, probably related to productivity, and ii) a great diversity of habitats from tropical rainforest to Alpine tundra. A similar association is apparent across the Indian subcontinent: 80% of all land and freshwater bird species can be found in the vicinity of the Himalaya, and within the Himalaya the wetter

southeast has a greater diversity of bird species than the drier northwest. Stainton and Polunin (1984) note similar patterns among the flowering plants.

As one moves from the northwest to southeast along the Himalaya, roughly 10% of all species occurring at one location are absent at a location 250 km further on. As one moves from southeast to northwest, the figures are more or less comparable, except from Nepal onwards, where about 30% of all species present at one location are missing from a location 250 km further northwest. The result is a steep decline in species diversity as one moves from west Nepal to northern Pakistan (as noted by Meinertzhagen 1928). The decline is associated with a latitudinal change of about 5 degrees, decreased precipitation and cooler spring weather.

The causes of turnover of species along the Himalayan transect are far from understood, so we undertook a comparison of the birdlife of two small sanctuaries separated by 250 km. We found that some species in one place are apparently replaced one-for-one by similar congeners in the other. Thus *Phylloscopus occipitalis* has a greater altitudinal range in Kashmir than in Himachal and this is associated with the absence in Kashmir of the similar *Phylloscopus reguloides*, occurring at high elevations in Himachal (Manali). The absence of *P. reguloides* from Kashmir is attributable to the absence of kharsu oak. We made a special study of the turnover of only *Phylloscopus* warblers (Price 1991, Price and Jamdar 1991), but more detailed studies of other species may result in similar explanations. At present, many patterns are unexplained. Several well-defined ecological groups present in Manali are simply missing from Kashmir, with no obvious counterparts. This includes some of the commonest birds in Himachal Pradesh such as a whole suite of ground foraging insectivores, a fantail-flycatcher and a minla.

One finding is that rarity in one sanctuary is no indication of absence from the other. At the

same time, some of the commonest species in one sanctuary are entirely missing from the other. A possible explanation is that conditions in the non-breeding season limit population sizes. If this is the case, then subtle shifts in breeding requirements may be sufficient to concentrate the species in one location. For example, *Phylloscopus tytleri* has a very small range in Kashmir and northern Pakistan (where it is abundant) but does not occur in Manali. Price (1999) suggested that the population size of *P. tytleri* was severely limited by its specialised wintering requirements (the species is migratory and overwinters at relatively high altitudes in the central Western Ghats).

Our studies at Manali have revealed the presence of several species previously unrecorded in Himachal Pradesh (see Table 2 and Appendix II). Most striking was the discovery of *Pnoepyga immaculata*, previously thought to be confined to Nepal (Martens and Eck 1991). This discovery highlights the fact that many species have patchy distributions. In our comparison between the two sanctuaries, we found several examples where absence from one or other sanctuary is a result of a patchy distribution rather than the true species' range limit lying between the sanctuaries. Six of the 10 species listed in Table 3 that are common in Overa but absent from Manali actually have large populations elsewhere to the east of Manali, in some cases extending through Nepal. Patchy distributions are more striking for species present in Overa and missing from Manali than the converse. This may reflect the much greater extent of the Himalaya to the east rather than the west.

Although range maps in Grimmett *et al.* (1999a) indicate several species with clearly patchy distributions on a regional scale, patchiness on a more local scale has scarcely been investigated, and needs more research. For example, we do not

know how extensive the distribution of *Pnoepyga immaculata* is beyond Manali. As a second example, Gaston *et al.* (1993) never recorded *Luscinia brunnea* in their surveys of the Great Himalayan National Park, approximately 50 km to the south of Manali. However, this species is one of the commonest species at both Manali and Overa.

At any given locality, there is high species' turnover along the elevational gradient, and bird communities separated by 1,000 m altitude are more different than the communities in Manali and Overa at the same altitude. Hunter and Yonzon (1993) have recorded the presence of many species with restricted altitudinal ranges in Nepal and point to the need for preserves at all elevations. Despite this, there are large differences in species' composition at different localities along the Himalaya, and Arunachal shares less than one-quarter of its species with Pakistan. There is a tendency to treat the Himalaya as a unit with respect to conservation issues, because the threat of habitat destruction is universal throughout the range. This analysis demonstrates that the Himalaya is actually quite diverse, and each area has its own needs. Each area must have its own nature preserves if Himalayan biodiversity is to be conserved.

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APPENDIX I: Additions/corrections to the Overa Sanctuary list (in Price and Jamdar 1990, 1991)

1. Price and Jamdar (1990, 1991) reported on the birds of Overa Sanctuary based on 3 years' fieldwork (1985-1987). Our subsequent work at Overa for 1-2 months in each of the years 1988, 1989, 1990 and 1991, confirmed the altitudinal distributions previously reported and confirmed breeding for some species.
 2. One additional species was recorded: large pied wagtail *Motacilla maderaspatensis* near Overa village.
 3. In Price and Jamdar (1990), we stated that two species, *Mycerobas icteroides* and *Carpodacus rhodochrous* bred throughout the entire altitudinal range that we studied (2,430-3,725 m). Although we recorded both species throughout the range, we are not sure that they breed in all locations. In particular, it remains to be determined that both the species breed at the highest and lowest altitude sites, and it appears unlikely that *M. icteroides* breeds at the highest altitude.
 4. In Price and Jamdar (1991), we noted that *Phylloscopus reguloides* is absent from Overa and were unsure where *P. reguloides* and *Phylloscopus occipitalis* breed in sympatry. We now know they occur sympatrically from the Kashmir border in the Chamba region of Himachal Pradesh to at least the Nepal border in Kumaon (including Manali). *P. reguloides* breeds at generally higher altitudes (e.g. Table 1 of this paper).
 5. In Price and Jamdar (1990), the generally uncommon spruce was not separated from fir in Table 1. In Table 4, printer's errors resulted in omission of some data and mismatching of columns. The altitudinal distributions and densities at high elevation of all species are given in Table 1 of this paper, and the mismatched columns in Price and Jamdar (1990) can be worked out.
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APPENDIX II: Rare or unusual birds recorded in Manali Sanctuary

Tibetan snowcock *Tetraogallus tibetanus*: A flock of 10 at 3,825 m on June 1, 2001. We do not know if this species is common, as we rarely visited higher altitudes.

Snow pigeon *Columba leuconota*: Eight birds seen on May 9, 2001, also seen rarely in Overa.

Black-naped green woodpecker *Picus canus*. Observed on May 24, 2002 at 2,430 m elevation.

Speckled wood-pigeon *Columba hodgsonii*. One bird seen on May 19, 2001 and two on May 8, 2002 in lower elevation forest, also seen once at Overa.

Grey treepie *Dendrocitta formosae*. One bird seen on May 19, 2001 at 3,100 m. Also seen in Manali town in May, 2002.

Long-tailed thrush *Zoothera dixonii*. A nest with 3 nestlings discovered at c. 3,100 m on May 23, 2002. Possibly more common in Manali and was previously overlooked by us.

Gould's shortwing *Brachypteryx stellata*. A male singing on June 6, 1994, in a juniper bush at c. 3,500 m. There are only a few earlier observations of this very distinctive species west of central Nepal, and none west of Uttaranchal. Despite searching, the species was not observed again.

Chaffinch *Fringilla coelebs*. A male singing on top of a cedar on May 4, 1994, at 2,000 m elevation. A rare winter visitor to the Himalaya (Grimmett *et al.* 1999b).

Little forktail, *Enicurus scouleri*. Observed twice in the sanctuary, once at c. 3,200 m. It is probable that the species breeds regularly but not confirmed, for watercourses were not regularly checked.

Yellow-browed tit, *Sylviparus modestus*. A pair feeding 4 young in a moss cup in hole in tree, June 11, 1997 at 2,750 m.

Grey-cheeked flycatcher-warbler, *Seicercus poliogenys*. A male singing at 2,500 m in a chestnut grove, first seen May 17, 2001, still present June 26, 2001, and still singing loudly and presumably unmated. Apart from possible records by Green (1986) in atypical habitat, this species has not been recorded west of Central Nepal (Grimmett *et al.* 1999b).

Fire-tailed sunbird, *Aethopyga ignicauda*. A male was captured and present in the study area on rhododendron (c. 3,300 m.) throughout June, 1997. It may have bred.

Two species are in Table 3 (*Turdus rubrocanus* and *Phylloscopus affinis*) and are not repeated here.

APPENDIX III: Additional species of Manali

Many of the following species are found in Manali town and on agricultural land, but have been recorded along the lower boundary of the Sanctuary (I = Infrequently observed). Note that this list includes only those species not in Tables 1 or 2.

Brown-fronted pied woodpecker *Dendrocopos auriceps* (I)
 Small blue kingfisher *Alcedo atthis*
 Oriental cuckoo *Cuculus saturatus*
 Indian cuckoo *Cuculus micropterus* (I)
 Blue rock pigeon *Columbia livia*
 Common sandpiper *Actitis hypoleucos*
 Eurasian hobby *Falco subbuteo*
 Common hoopoe *Upupa epops*
 Rufous-backed shrike *Lanius schach*
 Yellow-billed blue magpie *Urocissa flavirostris*
 Eurasian golden oriole *Oriolus oriolus* (I)
 Asian paradise-flycatcher *Terpsiphone paradisi* (I)
 Brown dipper *Cinclus pallasii*
 Tickell's thrush *Turdus unicolor*
 Oriental magpie-robin *Copsychus saularis*
 Plumbeous redstart *Rhyacornis fuliginosus*
 Spotted forktail *Enicurus maculatus*
 Grey bushchat *Saxicola ferrea*
 Common stonechat *Saxicola torquata* (I)
 Common myna *Acridotheres tristis*
 Jungle myna *Acridotheres fuscus*
 Great tit *Parus major*
 Red-headed tit *Aegithalos concinnus*
 Himalayan bulbul *Pycnonotus leucogenys*
 Oriental white-eye *Zosterops palpebrosus*
 Brown-flanked bush-warbler *Cettia fortipes*
 Streaked laughingthrush *Garrulax lineatus*
 Rufous sibia *Heterophasia capistrata* (I)
 House sparrow *Passer domesticus*
 Cinnamon tree sparrow *Passer rutilans*
 White wagtail *Motacilla alba*
 Large Pied wagtail *Motacilla maderaspatensis*
 Grey wagtail *Motacilla cinerea*
 Spotted munia *Lonchura punctulata* (I)
 Yellow-breasted greenfinch *Carduelis spinoides*
 Eurasian goldfinch *Carduelis carduelis*
 Common rosefinch *Carpodacus erythrinus*
 Grey-headed bunting *Emberiza fucata*
 Rock bunting *Emberiza cia*.

Note: *Cettia fortipes* has been recorded up to 2,225 m and *Rhyacornis fuliginosus* at 2,700 m. Both these species are of interest, in that they appear to occur at much higher elevations in Overa than in Manali. *Emberiza cia* has been recorded up to 3,200 m in Overa, but only 2,000 m in Manali. *Garrulax lineatus* has been recorded

